

# Annual Report 2014





Eawag, the Swiss Federal Institute of Aquatic Science and Technology, is part of the ETH Domain. This comprises the Swiss Federal Institutes of Technology in Zurich (ETHZ) and Lausanne (EPFL), Eawag and three other independent, application-oriented research institutes – the Paul Scherrer Institute (PSI), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and the Swiss Federal Laboratories for Materials Science and Technology (Empa). Nationally rooted and internationally networked, Eawag is concerned with concepts and technologies for the sustainable management of water resources and aquatic ecosystems. In cooperation with universities, other research centres, public authorities, the private sector and NGOs, Eawag strives to harmonize ecological, economic and social interests in water, providing a link between science and practical applications. In total, 491 staff are employed in research, teaching and consulting at the Dübendorf (Zurich) and Kastanienbaum (Lucerne) sites.

#### Cover photo

In 2014, the Blue Diversion Toilet was successfully field-tested in a slum district of Nairobi. This Eawag project is an example of effective knowledge transfer to developing countries, which in turn depends on solution-oriented research and inter- and transdisciplinary cooperation. (Photo: Eawag and EOOS)

# Editorial



Bridging theory and practice is one of Eawag's principal goals. In 2014, the results of Eawag's long-term commitment to solution-oriented research were highly visible. Eawag researchers played a major role in the National Research Programme on "Sustainable Water Management" (NRP 61), which concluded last year. Eawag also provided scientific input for the sustainable use of thermal energy from lakes, for prioritizing river revitalization and for understanding the environmental impacts of plant protection chemicals.

## Scientific excellence as a basis for solution-oriented research

Continual engagement with practice is critical to the development of solution-oriented research. Because the timescale for research is much longer than for practice or policy, research must be forward-looking and anticipate future societal needs. Eawag's practice-oriented programme of continuing education (Peak) – which celebrated its twentieth year in 2014 – is an important avenue for contact and dialogue between Eawag researchers and water professionals in administration, industry and consulting. Problems in practice do not confine themselves neatly to academic disciplines; with experience and expertise in interdisciplinary research, Eawag is well positioned to collaborate with stakeholders in joint, solution-oriented research projects. The capacity to make such contributions is supported, at a fundamental level, by Eawag's commitment to excellence. We are very proud of the recognition granted to Eawag's projects, researchers and students in the past year.

## Innovation and investment for the future

To ensure scientific excellence and to adapt to research needs, we are continuing to invest in modern infrastructure. Eawag's "Aquatikum", a new facility to house large-scale experiments, was completed at the end of 2014. Installation of equipment and infrastructure has already begun, and experiments will soon be up and running. We will shortly begin construction of an outdoor facility for ecological experiments, which will be able to start in spring 2016. We also anticipate that construction of the "backbone" (frame) of the experimental Nest building will be completed by the end of 2015; Eawag is cooperating with Empa on this major project, which will allow us to test novel processes and infrastructure for water and wastewater management in a fully realistic situation.

Eawag is always interested in improving and expanding its capacity for knowledge transfer and outreach. In 2014, we launched two Moocs (massive open online courses) on water, sanitation and hygiene in developing countries in collaboration with the EPFL. We also look forward to increasing our contacts with professional colleagues and stakeholders in French-speaking Switzerland this year, with our annual Info Day being held in Lausanne.

Janet Hering  
Director



Aldo Todaro



Sabine Rock



IWA



Andri Bryner



Andres Jordi



Fabian Suter



Setac

# Highlights of 2014

**1 Valuable urine-based fertilizer.** In collaboration with the water authority in Durban (South Africa), an interdisciplinary Eawag research team has developed a method which allows nutrients to be recovered from source-separated urine at small treatment plants and then sold as fertilizers. This smart sanitation system should reduce environmental impacts and stimulate local entrepreneurship. Durban now plans to construct a larger plant so that more households can be involved in the urine collection scheme (page 7). Large-scale urine treatment is also under discussion in Switzerland: Eawag intends to begin serial production of plants in cooperation with industrial partners. Photo: Pilot reactor at Eawag.

**2 Growing pressure on water resources.** In many parts of Switzerland, water resources are under much greater pressure from social and economic developments, such as urban sprawl, than from climate change. There is thus an urgent need for improvements in groundwater protection. This was one of the conclusions of the National Research Programme on “Sustainable Water Management” (NRP 61), which ended in November 2014. Eawag researchers led 5 of the 16 projects in NRP 61 and participated in 3 others. Eawag scientists were also responsible for 2 of the 4 thematic syntheses (page 7). Photo: End-of-project panel discussion.

**3 Innovation award for Blue Diversion Toilet.** The Blue Diversion Toilet – jointly developed by Eawag and the design firm EOOS – won the International Water Association’s Project Innovation Award for applied research. It is also being exhibited at the “Deutsches Museum” (Masterpieces of Science and Technology) in Munich until January 2016. Following successful field tests in Nairobi, the project team is now seeking industrial partners and investors so that further experience can be gained with a mass-

produced version. Photo: Project leader Tove Larsen at the award ceremony.

**4 Federal Councillor visits Eawag.** Visiting the institute in August 2014, Swiss Education & Research Minister Johann Schneider-Ammann said that Eawag was one of the country’s education and research “flagships”. He emphasized that parliamentary backing for Eawag was very strong and commended the institute’s consistent support for women and families, as well as its commitment to sustainability (page 21). Photo: Frederik Hammes explains the flow cytometry method to the Federal Councillor.

**5 Event to celebrate Chriesbach river revitalization.** An estimated 500 people attended the public event celebrating the completion of the habitat enhancement project on Eawag’s doorstep. After the official opening by Markus Kägi (Head of Canton Zurich’s Building Department), the attractions for visitors included guided tours (explaining the revitalization and other Eawag activities), fishing macroinvertebrates out of the stream, or simply sitting on the bank enjoying the sunshine. The project to restore the diversity of the Chriesbach habitat was led by Canton Zurich, with scientific support provided by Eawag. The stream now also serves as a research site and recreational area. Photo: Duck race on the Chriesbach.

**6 Innovative e-learning initiative.** In 2014, Eawag ran two Massive Open Online Courses (Moocs) – on household water treatment and sanitation system planning – in collaboration with the EPFL. Further Moocs are planned. These free courses, offered in English with French subtitles, are designed for students and water professionals, particularly in developing countries. The first course attracted over 8000 participants (page 13). Photo: Recording session for a Mooc.

**7 Dialogue between academia, government and industry.** Eawag scientists played a leading role in the organization of the 24th Annual Meeting of the Society of Environmental Toxicology and Chemistry (Setac Europe). This international event, held at the Basel Congress Centre, emphasized the need to address environmental problems by building bridges between science and policy. The scientific and social programmes at the five-day conference provided ample opportunities for dialogue “across bridges, borders and boundaries”.

# World-class research supporting practice and policymaking



In Eawag's Molecular Genetics Laboratory, lab technician Salome Mwaiko performs genome sequencing on various organisms. Modern analytical methods of this kind allow evolutionary biologists Ole Seehausen and Katie Wagner (in the background) to study the genetic diversity of aquatic organisms. (Photo: Aldo Todaro)



### **Society and environment**

Eawag's research focuses on water for human welfare and ecosystem function, and on the management of competing demands in the water sector. It is oriented towards topics of practical relevance and societal needs.

### **Sound basis for policymaking**

Eawag researchers deliver a sound scientific basis for decision-making and regulation in the water sector. For example, the decision taken at the federal level to upgrade large wastewater treatment plants so as to reduce discharges of micropollutants was underpinned by years of research at Eawag. The institute is now also monitoring the effects of this programme. In the National Research Programme on "Sustainable Water Management" (NRP 61), Eawag researchers led 5 of the 16 projects and were involved in 3 others (page 7). In collaboration with the Federal Institute for Forest, Snow and Landscape Research (WSL), Eawag has launched a programme to investigate the social and environmental impacts of Switzerland's energy transition. It is also participating in two new research programmes (NRP 70 and 71) supporting the implementation of the Swiss Energy Strategy 2050.

### **Cutting-edge technologies**

Eawag researchers develop innovative technologies to address environmental problems. In collaboration with Empa, Eawag is constructing the modular experimental building Nest, which will be used by the two institutes – together with indus-

trial and scientific partners – for research on new forms of living and working, innovative construction methods and energy-efficient technologies (page 23). Eawag has cooperated with partners in South Africa on the development of a sanitation system which reduces water pollution, produces valuable fertilizers and stimulates local entrepreneurship (page 7).

### **International research**

Eawag researchers maintain close contacts with water professionals, who collaborate in or provide input for projects. Here, a key role is played by Eawag's Advisory Board, which includes representatives from industry, parliament, associations, federal agencies and NGOs. Eawag's highly regarded expertise is based on excellence in science and applied research. Its status as one of the world's leading water research institutes is underlined by numerous publications in renowned journals (page 7). Researchers are regularly honoured for their work (page 21); last year, for example, Juliane Hollender was elected as a member of the Swiss National Science Foundation's Research Council, while Kathrin Fenner received a prestigious Consolidator Grant from the European Research Council.

### **From cell to ecosystem**

Eawag's research is interdisciplinary and involves engagement with stakeholders. Researchers adopt a systemic approach, seeking to understand processes and relationships at every level – from cell to ecosystem.

Max Maurer



1

Continued urban development in Switzerland will place increasing pressure on water resources, including groundwater. According to Eawag researchers involved in NRP 61, socio-economic factors will have a greater influence on water resources and resource use than climate change.

Urine collected by the Durban water service is treated in a pilot plant. In the first step, ammonia is nitrified; the nitrogen is thus stabilized, so that it is not released as gaseous ammonia during urine storage and distillation. Stabilization also removes the pungent odour. The liquid is then evaporated to produce a concentrated nutrient solution.

2



Maximilian Grau

Aldo Todaro



3

An incredible variety of cichlid species have developed in African lakes. As shown by Eawag studies, this species richness is due to genetic diversity and local speciation processes. Using genetic methods, researchers are now also investigating the origins of fish diversity in Swiss lakes; initial results suggest that similar mechanisms are involved.

## 1 Water resources: climate change and human demand

How will “Europe’s water tower” be affected if climate change leads to rising temperatures and more intense summer droughts? What developments will shape the future use of Switzerland’s water resources? Answers to these questions were sought by the National Research Programme on “Sustainable Water Management” (NRP 61), in which Eawag researchers played a leading role. The programme – launched in 2010 – was completed in 2014.

The effects of rising temperatures are expected to be most pronounced in mountainous areas: according to certain scenarios, around 90 per cent of all glaciers will have disappeared by the end of this century. The snowline will continue to rise. Receding glaciers will give way to new lakes, creating new opportunities for tourism and the water sector – but also increasing the risk of outburst floods.

In the densely populated, intensively used Central Plateau, however, socioeconomic and technical developments will have a much greater influence on water resources and resource use than the climate. For example, the demand for irrigation in 2050 will largely depend on future agricultural policy. Economic and population growth are also key factors: urban development in groundwater protection zones will give rise to resource-use conflicts. Groundwater will also increasingly be used for heating or cooling.

NRP 61 concludes that the Swiss water sector is not optimally prepared to meet these challenges: overarching visions and strategies are lacking, as well as specific coordination between communes and cantons. The researchers recommend that water management should be integrated into all policy areas; to this end, a national water strategy should be developed at the federal level.

## 2 Urine for a good harvest

In South Africa, municipal authorities are required under the constitution to provide appropriate sanitation services for all households. Given the scarcity of water and the lack of wastewater infrastructure in suburban areas of Durban, the local authorities have provided around 90,000 households with dry (non-flush) diversion toilets since 2003.

Separate collection of urine makes sense, as it accounts for a large proportion of the nutrients – such as nitrogen or phosphorus – which otherwise have to be removed at wastewater treatment plants. And if urine is appropriately treated, the nutrients recovered can be used as fertilizers.

The authorities in Durban therefore launched a project entitled VUNA (meaning “harvest” in the Zulu language) in collaboration with Eawag, the University of KwaZulu-Natal, and the Federal Institutes of Technology in Zurich and Lausanne. With funding from the Bill & Melinda Gates Foundation, the project partners studied the entire nutrient recovery system – from urine collection to finished fertilizer product – for the first time.

A urine collection service was established in Durban, and the researchers developed a new two-step method for separating water from nutrients in urine: first, half of the nitrogen present in urine in the form of ammonia is converted to nitrate with the aid of bacteria. In the second step, the liquid is evaporated to produce a concentrated nutrient solution – just 3 per cent of the original volume. The method has been tested in pilot plants at Eawag and in Durban. Compared with artificial fertilizers, the performance of the urine-based product is excellent. As well as the three most important nutrients – nitrogen, phosphorus and potassium – the urine-based fertilizer contains numerous trace elements, such as iron, zinc and boron. Although the challenge of pharmaceutical residues remains to be overcome, it has already

been shown in the laboratory that these can be removed via an additional treatment step, using activated carbon.

## 3 Genetic diversity facilitated cichlid evolution

The 500 cichlid species now found in Lake Victoria (East Africa) developed over a period of just 15,000 years. To investigate how this rapid speciation was possible, 27 research institutions around the world joined forces to retrace the history of the genomes of five cichlid species. The findings, published in *Nature*, show that numerous genetic mutations were amassed in the ancestral species during a period of low selection pressure. Ole Seehausen, a fish and evolutionary biologist at Eawag and co-leader of the study, explains: “At that time, this variation was probably not of much use, but it became incredibly useful when the fish colonized the East African Lakes. Here, the diverse ecological niches suddenly provided opportunities for a wide variety of adaptations.” Accordingly, the researchers emphasize that the maintenance of genetic diversity is crucial to the conservation of biodiversity.

Another recent study by Seehausen and his colleagues demonstrated that species richness is also largely dependent on local speciation processes: the exceptional diversity of cichlids in African lakes was found to be mainly attributable to local development of new species, rather than immigration of existing species. Diversity is influenced not only by lake area and solar radiation, but also in particular by lake depth: deep lakes provide the most favourable conditions for a variety of ecological niches.

Eawag researchers collect water for pesticide screening. For 31 substances, concentrations exceeded the limit specified in the Water Protection Ordinance. As composite samples taken over a 2-week period were used, the researchers concluded that short-term peak concentrations could in some cases be much higher – above the threshold level for acute toxicity.

4



Ivo Farkas

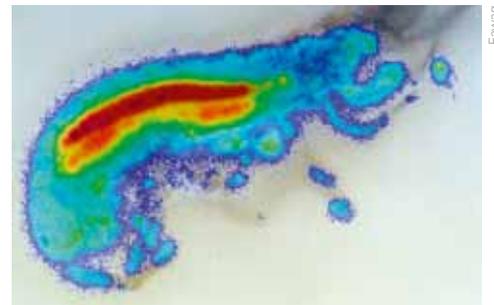
Linda Strand



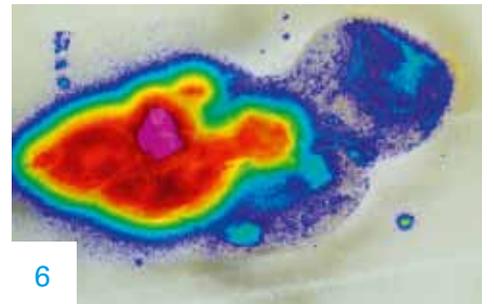
5

In Kampala, the pilot kiln fuelled by dried faecal sludge, operating at 800 degrees Celsius, produced bricks comparable in quality to those made using other biofuels.

The distribution of toxicants differs markedly in pond snails and freshwater shrimps. Toxicity is determined by concentrations in nervous tissue, which are much higher in the shrimp (top) than in the snail (bottom).



Eawag



6

### Bacteria: identity and diversity

For many years, it was believed that genetic mutations enable certain bacteria to survive antibiotic treatment. Recently, however, scientists have discovered that genetically identical individuals may differ in their tolerance to antibiotics. The mechanisms underlying this variation were investigated by environmental microbiologist Martin Ackermann and co-workers. Bacteria were studied at the single cell level in microfluidic chips, using time-lapse microscopy and quantitative image analysis. The researchers showed that bacterial cells in which virulence genes are expressed show increased survival after exposure to antibiotics. Growth retardation resulting from the expression of virulence genes also reduces susceptibility to antibiotics.

The findings demonstrate the existence of phenotypic variation even within genetically identical populations of bacteria. The researchers believe that this diversity allows bacteria to adapt to sudden changes in the environment. The same experimental set-up can also be used to study such phenomena in an aquatic environment – for example, how diversity enables bacteria to react to changes in nutrient availability.

#### 4 Cocktail of pesticides detected in Swiss rivers

A comprehensive pesticide-screening study has shown that Switzerland's rivers are not quite as clean as has previously been supposed. In the study, samples collected from five medium-sized rivers were analysed for all soluble synthetic plant protection products and biocides. Of a total of roughly 300 authorized active substances, 104 were detected in the water samples.

For 31 substances, concentrations exceeded the limit of 0.1 micrograms per litre specified in the Water Protection Ordinance; in certain cases, concentrations were even found to exceed 1 microgram per litre. Concerns were raised in particular by the finding that, on average, 40

substances were detected per sample. In 78 per cent of samples, the combined pesticide concentration was over 1 microgram per litre. Even if concentrations of individual substances do not exceed the ecotoxicological water quality criteria, aquatic organisms could be adversely affected by pesticide mixtures. Juliane Hollender, Head of the Environmental Chemistry department, comments: "It's becoming increasingly clear that what's needed, as well as tests for individual substances, is a risk assessment of the combined toxicity."

According to a European study in which Eawag scientists participated, chemical pollution also poses an ecological risk for around half of all waterbodies across Europe. In around 15 per cent, there is even a risk of acute toxicity for aquatic organisms.

#### 5 Treated faecal sludge – an industrial fuel?

Worldwide, 2.7 billion people use pit latrines or septic tanks which are not connected to a sewer system. While on-site sanitation is a low-cost option, it is only sustainable if faecal sludge is collected, transported, treated and safely disposed of. In most cities of sub-Saharan Africa, however, faecal sludge is dumped directly into the urban environment. In collaboration with partners in Dakar (Senegal), Kampala (Uganda) and Accra (Ghana), Linda Strande and colleagues from the Department of Water and Sanitation in Developing Countries (Sandec) investigated whether resource recovery, an environmentally sound alternative, would be technically feasible and commercially attractive.

The study focused on the potential use of faecal sludge as an alternative fuel for the region's numerous cement and brick companies. The calorific value of faecal sludge was found to be sufficiently high for it to be able to compete with local biofuels. But before it can be used as a solid fuel, it has to be dried. The drying process was studied at an experimental

facility in Dakar. Finally, in two specially constructed pilot-scale kilns, it was demonstrated that dried faecal sludge can be used for industrial processes with no loss of quality.

This type of reuse is also commercially attractive: the production of combustible fuels could generate revenues 2–35 times higher than the sale of faecal sludge as a soil conditioner.

#### 6 Measuring sensitivity to pesticides

Aquatic invertebrate species vary in their sensitivity to pesticides. For example, pond snails are much more tolerant than freshwater shrimps to the neurotoxic insecticides diazinon and imidacloprid.

Using imaging methods, researchers led by Kristin Schirmer of the Environmental Toxicology department, together with colleagues from Switzerland, the UK and Finland, revealed one of the factors contributing to this variation. In the shrimps, high concentrations of the toxicants are found in nervous tissue, while in the snails accumulation occurs in less sensitive regions of the body. With this new approach, it is possible to determine which substances affect particular organs, or are effectively eliminated, in different organisms. The sensitivity of aquatic invertebrates to pesticides can thus be systematically measured, modelled and explained. The method could also facilitate the development of new pesticides which only act on specific target organisms and do not pose risks to other species.

# Valued experts and distinguished young researchers

In practice-oriented Eawag courses (Peak), water professionals can expand their knowledge or learn about new methods. Exchanges with professionals in the Peak programme make an important contribution to knowledge transfer. (Photo: Aldo Todaro)

### Practice-oriented education

Eawag scientists make a significant contribution to the practice-oriented education of water professionals, with a total teaching commitment of over 4700 hours within the higher education sector in 2014 (page 27). Teaching activities are based on the experts' own research and also cover niche areas. Particular weight is attached to practical training in the lab and field. Collaboration with universities of applied sciences has been intensified.

### Successful doctoral students

In 2014, Eawag scientists supervised around 140 doctoral dissertations and 145 Bachelor's and Master's theses. The doctoral students are from 34 different countries, with half coming from Switzerland or Germany. Trainees benefit from the transdisciplinary approach: while working within individual disciplines, they learn to adopt a systemic perspective. The selection of doctoral candidates and supervision of PhD students involves a structured procedure. Eawag thus ensures that the most capable young scientists engage in research – and obtain optimal support. Eawag's doctoral students frequently receive awards for their work and are in demand on the employment market (page 13).

### Establishing contacts

Eawag organizes summer schools which attract young scientists from around the world. As well as focusing on a specific

topic, these events provide opportunities for participants to interact with eminent researchers. In 2014, the Systems Analysis, Integrated Assessment and Modelling department held a Summer School on Environmental Systems Analysis.

### Knowledge transfer to practice

For Eawag, continuing education of water professionals is a fundamental responsibility. The practice-oriented course (Peak) programme, which has been running for over 20 years, remains very popular (page 13). Peak courses communicate recent research findings and promote dialogue between research and practice. This is also the aim of the annual Info Day, which was attended by around 300 professionals in 2014 (page 13). In organizing these courses and information events, Eawag collaborates with professional bodies.

### New forms of teaching

To reach out to professionals in developing countries, Eawag is investing in new forms of teaching, such as massive open online courses (Moocs). In 2014, the Department of Water and Sanitation in Developing Countries (Sandec) ran two Moocs in collaboration with the EPFL (page 13). Through its Eawag Partnership Program for Developing Countries (EPP), Eawag promotes knowledge transfer to developing and emerging countries. The EPP offers fellowships allowing talented Master's or PhD students to carry out research at Eawag for 3–6 months.

Peter Penicka



1

The Moocs on household water treatment and sanitation system planning attracted over 8000 and 6000 participants respectively. Of the participants, 48 per cent were from low- or middle-income countries.

Eawag alumnus Sébastien Meylan visiting the site of a hazardous waste landfill remediation project in Monthey (Canton Valais). Meylan appreciates the pragmatic approach adopted in industry. And, while less time is available for in-depth studies, the decision-making processes are efficient: "For my projects – unlike in the research sector – I don't first have to find the funding, I can start straightaway."



Cirno

2

Andres Jordi



3

At Eawag's Info Day, around 300 water professionals were informed about recent research on aquifers fed by infiltrating river water. Although the soil acts as a natural barrier to contaminants, this system is not infallible.

## 1 Online teaching – global learning

The Department of Water and Sanitation in Developing Countries (Sandec), in collaboration with the EPFL, has launched a series of massive open online courses (Moocs) on the theme of Water, Sanitation and Hygiene (Wash) in developing countries. The courses are addressed to students and water professionals worldwide. The first module, which began in April 2014, provided an introduction to water treatment options at the household level. The second module, which started in October, covered the planning and design of sanitation systems and technologies. The Moocs are free of charge and run for 5 weeks. In 2015, Sandec will be repeating the first course, with adapted content, and also plans to offer a new course on Solid Waste Management in developing countries.

## 2 Sébastien Meylan: “I can now achieve a lot”

Kitted out in hard hat and orange jacket, Sébastien Meylan enters a large, tent-like structure where excavators are loading soil into containers. As the project manager responsible for the remediation of the Pont Rouge hazardous waste landfill (Canton Valais), Meylan – a chemical engineer and Eawag alumnus – regularly inspects the site. For around 20 years, waste was disposed of here – at that time quite legally – by local chemical companies. Meylan’s employer, Cimo (Compagnie industrielle de Monthey), has been entrusted with the remediation works. As he explains: “Remediation of a contaminated site is a complex project. Before remediation could begin in 2011, several years of preparatory work was required – measurement of pollutants, analyses, technical investigations and planning.”

Sébastien Meylan has been involved from the start. The aim of the remediation project is to prevent further leaching of contaminants into groundwater. Meylan studied the mobility of pollutants in the environment for his doctoral dissertation at Eawag. Then, after a stint as a

postdoc, he decided to work in industry: “At Eawag, I had the opportunity to carry out high-level research. In my current position, I can use my expertise to achieve a lot.”

Project management skills are another key requirement and, here too, Meylan’s experience at Eawag stood him in good stead: as a postdoc, he was responsible for managing an interdisciplinary research project. His specialist training has proved invaluable for collaborating effectively with various environmental consultancy firms – where he frequently encounters other Eawag alumni.

## Peak courses: transferring knowledge to practice

What native fish species occur in Swiss waters? What habitats do they favour, and what risks are posed by introduced species? This was the subject of a practice-oriented Eawag course (Peak) attended by over 40 water professionals.

While introductory courses, such as the one on fish species, provide a basis for understanding environmental problems, in-depth courses offer an overview of particular issues based on specific examples and case studies. Last year, for example, one of these courses explored innovative business models for affordable and sustainable sanitation and water services in low-income countries. In applied courses, participants learn practical methods – e.g. the use of high-resolution mass spectrometry in the analysis of organic micropollutants. In 2014, a total of seven Peak courses were held, with over 270 participants.

For over 20 years, Peak courses have been among the most popular training events for professionals from industry, government and engineering/environmental consultancies. An important element has always been the opportunity for exchanges among participants and between research and practice.

## 3 Info Day on water supplies and bank filtration

80 per cent of Switzerland’s drinking water is sourced from groundwater, and a third of these aquifers are fed by infiltrating river water. Contaminants are removed as they pass through the soil, and bank filtration is generally the only barrier between river and drinking water. But can this system continue to guarantee safe water supplies in the future? At last year’s Eawag Info Day, the latest findings of research on the topic of “Water supplies and bank filtration – a system under pressure?” were presented to almost 300 scientists, water professionals, administration officials and policymakers.

The extent to which contaminants are retarded or degraded as they pass through the subsurface was shown by an Eawag project on the Thur. Almost 100 substances were detected both in river and in groundwater, although concentrations in groundwater were generally lower since various chemicals are rapidly eliminated as they pass through the infiltration zone – in some cases even within the first few metres. During the winter, however, degradation is slowed as a result of lower water temperatures.

These findings show that, while the soil is an effective filter, it is not infallible. The quality of river water is thus crucial for bank filtration. In recent Eawag studies, between 100 and 160 different organic micropollutants were detected in effluents from wastewater treatment plants. The adoption of measures for river restoration and for micropollutant elimination at wastewater treatment plants are thus steps in the right direction, exemplifying Switzerland’s preventive approach to water protection.

# Permanent dialogue and close collaboration with stakeholders

Since 1993, chemical substances in the Rhine have been systematically observed at the international Weil am Rhein monitoring station (RÜS). Environmental chemist Matthias Ruff (left) discusses the results of micropollutant analysis with Steffen Ruppe of the RÜS. (Photo: Aldo Todaro)

### Interaction with professionals

Eawag promotes the transfer of research findings to practice. Eawag scientists collaborate with water professionals in numerous projects (page 17). They offer consultancy services which cannot be provided by the private sector. They feed their expertise into the work of national and international committees, and maintain an extensive network of contacts. Through service contracts, the latest knowledge and new technologies from Eawag find their way into practice.

### Valued competence centres

Eawag operates a number of competence centres which address challenges arising in the water sector. These centres promote exchanges between scientific disciplines and practice and initiate joint research projects. For example, in the "Regional Water Supplies Basel-Landschaft 21" project, the Competence Centre for Drinking Water is collaborating with the cantonal authorities on a study of ground and drinking water contamination in various parts of the canton. The Fishery Advice Centre (Fiber) – jointly run by Eawag, the Federal Office for the Environment and the Swiss Fishing Federation – provides information on scientific findings and advice on aquatic ecology and fishery management. The Eawag/EPFL Ecotox Centre studies and assesses the effects of chemicals on the aquatic environment (page 17). Eawag participates in the Water Agenda 21 network, which offers a platform for dialogue among the various actors in Switzerland's water sector.

### Extensive networks

Dialogue with water professionals is facilitated by collaboration with professional associations. Eawag has traditionally maintained close links with the Swiss Water Association (VSA). In recent years, collaboration with the Swiss Gas and Water Industry Association (SVGW) has been intensified, and the 2014 Info Day was organized in partnership with this body (page 13). Eawag also maintains contacts with industry: it has been agreed that there should be regular exchanges of ideas with the Chemistry, Pharma and Biotech Business Association (Science Industries). Cantonal and federal authorities are also key partners; for example, Eawag researchers are supporting Canton Basel-Stadt in the analysis of micropollutants at the Weil am Rhein monitoring station. Over the past few years, they have provided scientific and technical input for the reorganization of analytical procedures at this facility.

### User-oriented publications

Eawag's research results are presented in formats suitable for users. In 2014, three factsheets were published containing scientific information on topics of political relevance (page 17). Factsheets offer background information and argumentation for policymakers. A handbook produced in partnership with the WHO Collaborating Center for Sanitation and Water in Developing Countries provides NGOs and authorities with practical guidance on addressing geogenic contaminants (arsenic and fluoride) in drinking water.

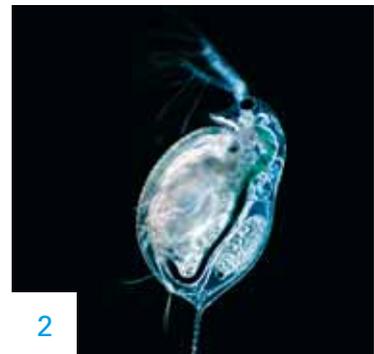
Markus Forte/Ex-Press/BAFU



1

Widening of the Linth channel at Benken (Canton St. Gallen). Rehabilitation measures should focus on improving connectivity and promoting near-natural hydro- and sediment dynamics and good water quality. They should also create the conditions that allow rivers to recover their natural dynamics.

Chemical mixtures can have toxic effects on daphnia and other organisms even if the individual substances are present in concentrations considered safe. This was shown by a ring test in which the Eawag-EPFL Ecotox Centre participated.



Piet Spaak

2

Sustainable energy from Lake Constance: a gigawatt of thermal energy could be used without adverse effects on the ecosystem or water quality. This is roughly equivalent to the output of a nuclear power plant.



iStockphoto

3

## 1 Setting priorities for rehabilitation projects

In the coming decades, around 4000 kilometres of rivers and streams are to be rehabilitated in Switzerland. But where are rehabilitation measures particularly worthwhile, and what types of measures are needed? To assist the cantons in their prioritization and planning efforts, the Federal Office for the Environment requested Eawag to develop decision-support materials.

To identify river reaches where ecological enhancement measures would be particularly appropriate, the researchers developed a prioritization procedure. A key selection criterion is the recovery potential of a watercourse. This will depend on the condition of the catchment and connections with the wider river network, and on the species available to recolonize restored areas. High priority attaches to areas with rare species or diverse habitats and to reaches with a special function – e.g. containing spawning grounds or serving as corridors for migration.

Based on an evaluation of 62 rehabilitation projects carried out in Germany and Switzerland, the researchers concluded that the prime goal should be connectivity. Measures should also promote near-natural hydro- and sediment dynamics and ensure good water quality.

In another study, fish biologist Armin Peter and co-workers are investigating how fish migration can be facilitated at run-of-the-river hydropower plants. While fish ladders or bypass channels allow sneep, barbel and other species to migrate upstream, fish swimming downstream along the main channel enter the turbines. Tests are being conducted in model channels to find out whether fish can be diverted with the aid of bar racks and louvres. The initial results are promising.

## 2 Risks of chemical cocktails

Chemical substances generally occur in the environment as complex mixtures. To study the risks posed by cocktails

of chemicals, the Eawag-EPFL Ecotox Centre participated in a ring test with 15 other laboratories. Two mixtures of pesticides, drugs, heavy metals and other substances were investigated for their toxic effects. In both mixtures, all individual substances were present in concentrations that are considered safe under the existing EU regulations. The scientists conducted 35 different bioassays with 11 organisms. The mixtures caused toxic effects in bacteria, nematodes, crustaceans, amphibians and fish. The results indicate that chemical mixtures may be harmful even if the individual pollutants occur in apparently harmless concentrations. This calls into question the current approach to chemical risk assessment, which is based solely on the toxicity of individual substances.

## 3 Lakes: a significant thermal energy source

Using energy from lakes for heating or cooling represents an attractive alternative to burning fossil fuels. But how much thermal energy can be withdrawn from a lake without producing adverse impacts on the ecosystem or water quality? This question was addressed by Alfred Wüest's Aquatic Physics Group, taking Lake Constance as an example, in a study supported by the Interreg IV programme.

A realistic scenario was developed, based on demand of around 1 kilowatt per person living near the lake. For a population of 1 million, the total demand is then 1 gigawatt or 2 watts per square metre of lake surface. To estimate the spatial and temporal distribution of temperatures in the lake, the researchers used a mathematical turbulence model. As well as various discharge rates and temperature differences, they considered a variety of water extraction and discharge depths. Modelling showed that there would be only minor effects on water temperature and negligible effects on lake mixing in the winter and stagnation in the summer. With 1 gigawatt of heat use, the surface temperature would change by no more than  $\pm 0.2$  degrees Celsius. The range of change would be even

smaller ( $\pm 0.1$  degrees Celsius) if heat extraction in the winter was offset by heat input (discharge of used cooling water) in the summer.

## Factsheets: guidance for policymakers

Eawag makes available the latest research findings on topics of political relevance for decision makers in parliament and administration. In the light of the current debate on pesticides, two factsheets were issued by Eawag in collaboration with the Ecotox Centre. The first presents the latest scientific knowledge on the occurrence and effects of pesticides in rivers, lakes and groundwater; the second covers the ecotoxicological assessment of pesticides in surface waters.

Eawag also issued a response to an article published in the *Neue Luzerner Zeitung*, in which members of the fishing community called for an increase in discharges of phosphorus from wastewater treatment plants around Lake Lucerne; the aim would be to stimulate fish growth and increase yields. Eawag is strongly opposed to this proposal. A key argument is the conservation of biodiversity: research has shown that high nutrient levels can lead to the disappearance of endemic species.

# Attractive employment conditions for outstanding performance

The "Kinderpavillon" offers children of Eawag and Empa staff a home from home. This childcare facility exemplifies Eawag's commitment to equal opportunities and progressive working conditions. (Photo: Aldo Todaro)

### Modern research infrastructure

Eawag provides an excellent working environment for its staff, with a first-class research infrastructure. Modern laboratories and high-end equipment mean that current research questions can be addressed using the latest tools for chemical and molecular biological analysis. Collaboration with the ETH Zurich Genetic Diversity Centre and Functional Genomics Centre further expands analytical capacity. The experimental treatment plant, cold and warm water aquaria and outdoor mesocosms facilitate large-scale experiments. An open-air lab on the revitalized Chriesbach river is now also available for research and teaching. Continuous investment in infrastructure ensures that Eawag is equipped for future research activities. In 2014, work on the new “Aquatikum” facility was largely completed (page 23).

Preparations have begun for the construction of 36 experimental ponds for studies under natural conditions.

### Exemplary environmental performance

Internal environmental management has always been a priority for Eawag (page 28), which is a pioneer among federal institutions in this regard. The newly built “Aquatikum”, for example, complies with the Minergie P-Eco energy efficiency standard. Eawag is committed to carbon-neutral travel and 100% renewable power and heat production. Other environmental measures include near-natural site landscaping, organic produce in the staff canteen, in-

centives for public transport use and cycling, and carbon offsetting for unavoidable air travel. An environment team promotes environmental awareness and proposes optimization measures (page 23). Eawag’s proactive efforts are in accordance with the initiative launched by the federal authorities in 2014 – “The Confederation: exemplary in energy”.

### Motivated staff

Eawag is committed to equal opportunities. In 2014, it participated in “Mentoring Deutschschweiz”, an academic mentoring programme for female doctoral or post-doctoral researchers. In collaboration with its sister institutes in the ETH Domain, it continued with a career planning initiative for young female researchers. Women are actively encouraged to take on managerial roles, and at 30 per cent the current proportion of female managers is above average. With the appointment of Tove Larsen, two women now serve on Eawag’s Directorate (page 21). In 2014, Eawag, together with Empa, the PSI and the WSL, launched the Swiss Dual Career Platform, which offers support for researchers’ partners or spouses in finding work and getting settled in Switzerland (page 23). For low-income families, support is provided for childcare at the Eawag-Empa nursery. As far as possible, employees with illnesses or disabilities are integrated into the work process. According to a recent survey, Eawag staff are highly satisfied with their work situation.

Andreas Jordi



1

Eawag hosted an event celebrating the completion of the Chriesbach revitalization project at Dübendorf.



Oliver Bartschlagler

2

Doctoral student Lisa Scholten receives the Otto Jaag Water Protection Prize at ETH Day.

Peter Penicka



3

During his 34 years at Eawag, Armin Peter conducted research on restoration ecology.

## Broad dialogue

### 1 Direct contacts with the public.

Spring 2014 saw the completion of the project to revitalize the Chriesbach, the river on Eawag's doorstep in Dübendorf. Around 500 children and adults – relatives and members of the public – accepted an invitation to celebrate and to find out more about Eawag's research in and around the Chriesbach. Among the day's highlights was a (plastic) duck race on the restored river, with attractive prizes for the winners.

**Fish Migration Day in Lucerne.** Also popular with the public was an information event held to mark World Fish Migration Day in May 2014. At a weir on the Reuss in the centre of Lucerne, experts from Eawag and from the city's Natural History Museum described the numerous barriers to fish migration in Switzerland's rivers.

**Visit from Federal Councillor Schneider-Ammann.** As well as knowledge transfer and contacts with the public, Eawag attaches great importance to dialogue with policymakers. In August 2014, Eawag received a visit from Johann Schneider-Ammann, Head of the Federal Department of Economic Affairs, Education and Research. The Federal Councillor took this opportunity to find out about current projects and hold discussions with researchers; Eawag, he noted, was one of the country's education and research "flagships".

### EU sends Chief Scientific Adviser.

EU officials also take an interest in Eawag's research activities. In May 2014, Professor Anne Glover, Chief Scientific Adviser to the President of the European Commission, met with Eawag researchers and members of the Directorate to discuss cooperation with other European research institutions.

## Awards

### 2 Industry and academic awards.

In the year under review, three dissertations by Eawag scientists received awards: Lisa Scholten (Systems Analysis) won the Otto Jaag Water Protection Prize; and ETH Medals were awarded to Pascal Wunderlin (Process Engineering) and Tobias Sommer (Surface Waters). Alexandra Fumasoli won a Huber Technology Prize 2014 "Future Water" for her Master's thesis on a method for recovering phosphate from urine. In addition, several researchers have been recognized for their publications. For example, environmental social scientist Bernhard Truffer received the IAMOT Research Publication Award for his numerous publications in the field of technology management. Christa McArdell (Environmental Chemistry) and Urs von Gunten (Water Resources & Drinking Water) were listed as Highly Cited Researchers by Thomson Reuters. Florian Altermatt (Aquatic Ecology) was awarded an SNSF Professorship; this position is associated with the Institute of Evolutionary Biology and Environmental Studies at Zurich University. Juliane Hollender, Head of the Environmental Chemistry department, was elected as a member of the Swiss National Science Foundation's Research Council.

## Personnel news

### 3 Long-serving researchers retired.

The year under review saw the retirement of several long-serving researchers. Jürg Beer, Honorary Professor at ETH Zurich, who had worked as a researcher in the Surface Waters department since 1988, left Eawag in January 2014. Armin Peter, Restoration Ecology group leader, retired at the end of 2014 after 34 years' service. Recognized in Switzerland as a leading expert on fish, his research focused in particular on downstream and upstream migration in engineered rivers.

**Changes in Eawag's Directorate.** In 2014, Tove Larsen, a group leader in the Urban Water Management department, became a member of the Directorate. Alfred Wüest, Professor of the Physics of Aquatic Systems at the EPFL, was also appointed to the Directorate. He succeeded Bernhard Wehrli, Professor of Aquatic Chemistry at ETH Zurich, who left office at the end of February 2015. The Federal Council reappointed Janet Hering as Director of Eawag for another four years; her third term of office began in January 2015.

In Water Resources & Drinking Water, Michael Berg, Contaminant Hydrology group leader, became the new Head of Department. He succeeds Rolf Kipfer, Environmental Isotopes group leader, who was in charge of the department from 2005 to 2015.

Peter Penicka



4

Eawag pays particular attention to employees' development potential.

The remodelled laboratory building ("Aquatikum") will house experiments on aquatic ecosystems and provide space for drinking water research.



5

Aldo Todaro

Stefan Kubli



6

PhD students from all four research institutes benefit from the training offered by the shared library.

## Equal opportunities

**A platform for networking.** As internationally renowned research centres, the institutes of the ETH Domain regularly recruit staff from abroad. Often, new employees are accompanied by a highly qualified partner, also keen to pursue career opportunities in Switzerland. To make it easier for trailing spouses to network and settle in, Eawag – along with its sister institutes Empa, PSI and WSL – has launched the online Swiss Dual Career Platform. Collaboration with the other research institutes should facilitate the development of a broad community, sharing ideas and advice.

**4 Staff survey bears fruit.** Based on inputs from the staff survey conducted in 2013, various measures have been adopted in personnel management. Leaders have been asked to pay particular attention not only to development potential, but also to the possibility of excessive work pressures among their staff. They are also required to review and optimize work processes within their teams. In 2014, these issues were highlighted at management training events.

## Infrastructure

**5 Old laboratory building remodelled.** On Eawag's Dübendorf campus, work on the conversion and extension of the 1968-vintage laboratory building continued in 2014. The new "Aquatikum" offers more space for researchers to realize large scale ecological projects. The multi-use facility will allow research to be conducted on model ecosystems under different environmental conditions. In the new labs, experiments will also be carried out by researchers from the Aquatic Ecology, Environmental Toxicology and Drinking Water departments. On the adjacent site, Eawag plans to construct an experimental pond facility in 2015.

## Nest – modular experimental building.

In August 2014, Empa, ETH Zurich, EPF Lausanne and Eawag laid the foundations for a modular experimental building known as Nest. Construction of the "backbone" began in the autumn; this will supply the independent living and work areas with water, heat and electricity. The modular units are exchangeable, allowing external firms and researchers from various disciplines to test building materials, energy management and infrastructure systems under real-life conditions. Eawag's contribution to the project involves a new wastewater infrastructure concept.

## Environmental management

**Exemplary energy use.** Major research facilities have to be regularly adapted to meet new requirements. Eawag uses these modernization phases to introduce sustainable energy concepts. For example, the recent renovation of the research facility at the Kastanienbaum site included measures to reduce the use of non-renewable forms of energy. In various stages, the building envelope was modernized and installations were renewed. The centrepiece is a new ventilation system comprising heat recovery and cooling with lake water. Thanks to the renovation, use of heating oil was sharply reduced in 2014. Eawag is thus assuming its exemplary function as a federal institution and addressing the challenges of the Energy Strategy 2050 for the operation of the ETH Domain.

## Collaboration within the ETH Domain

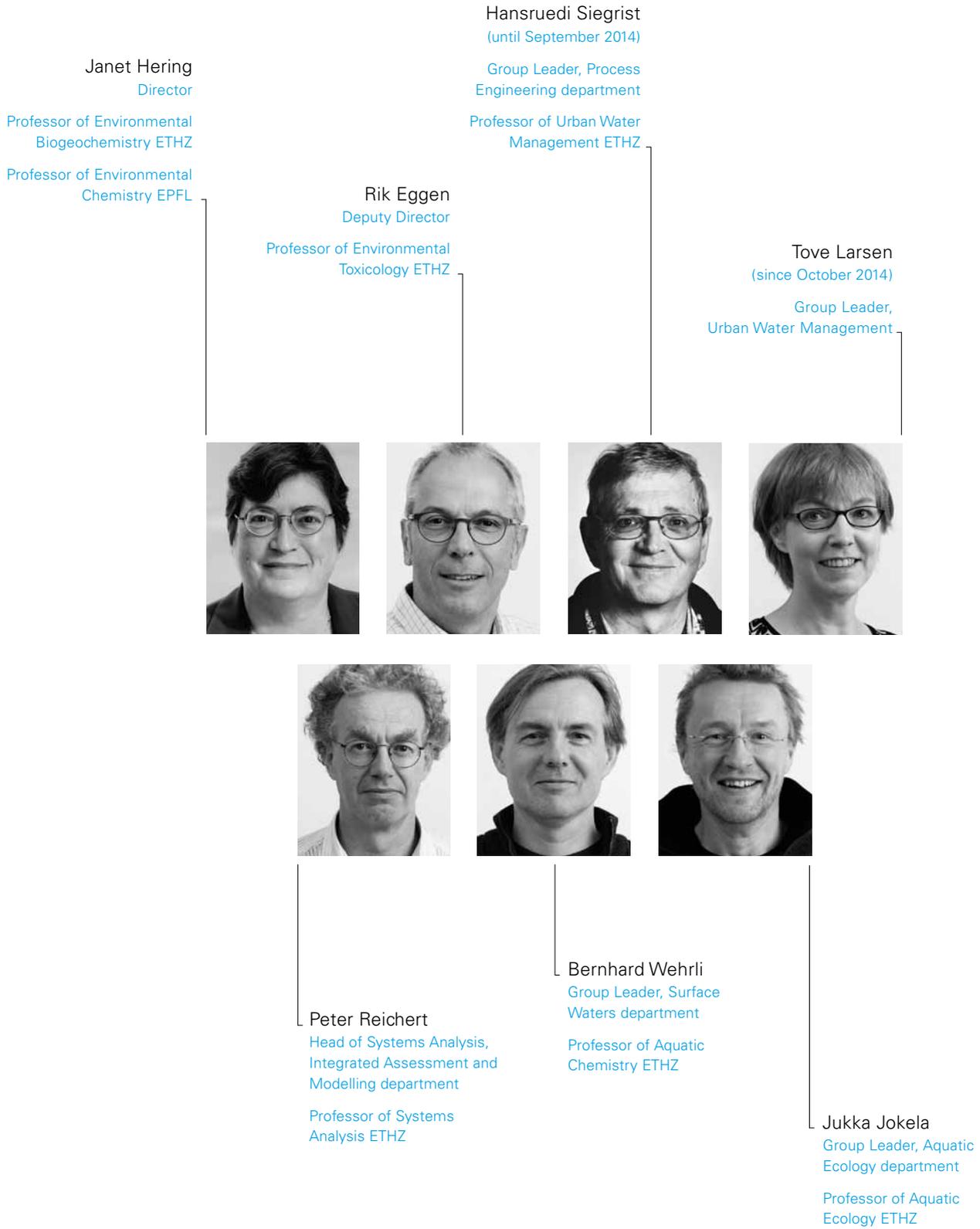
### 6 Joint courses for PhD students from the four research institutes.

As well as collaborating closely in research, Eawag, Empa, PSI and WSL exploit synergies in other areas. In 2014, the shared library (Lib4RI) further expanded its training activities for doctoral students from all four research institutes. Introductory courses enable young researchers to learn about searching and

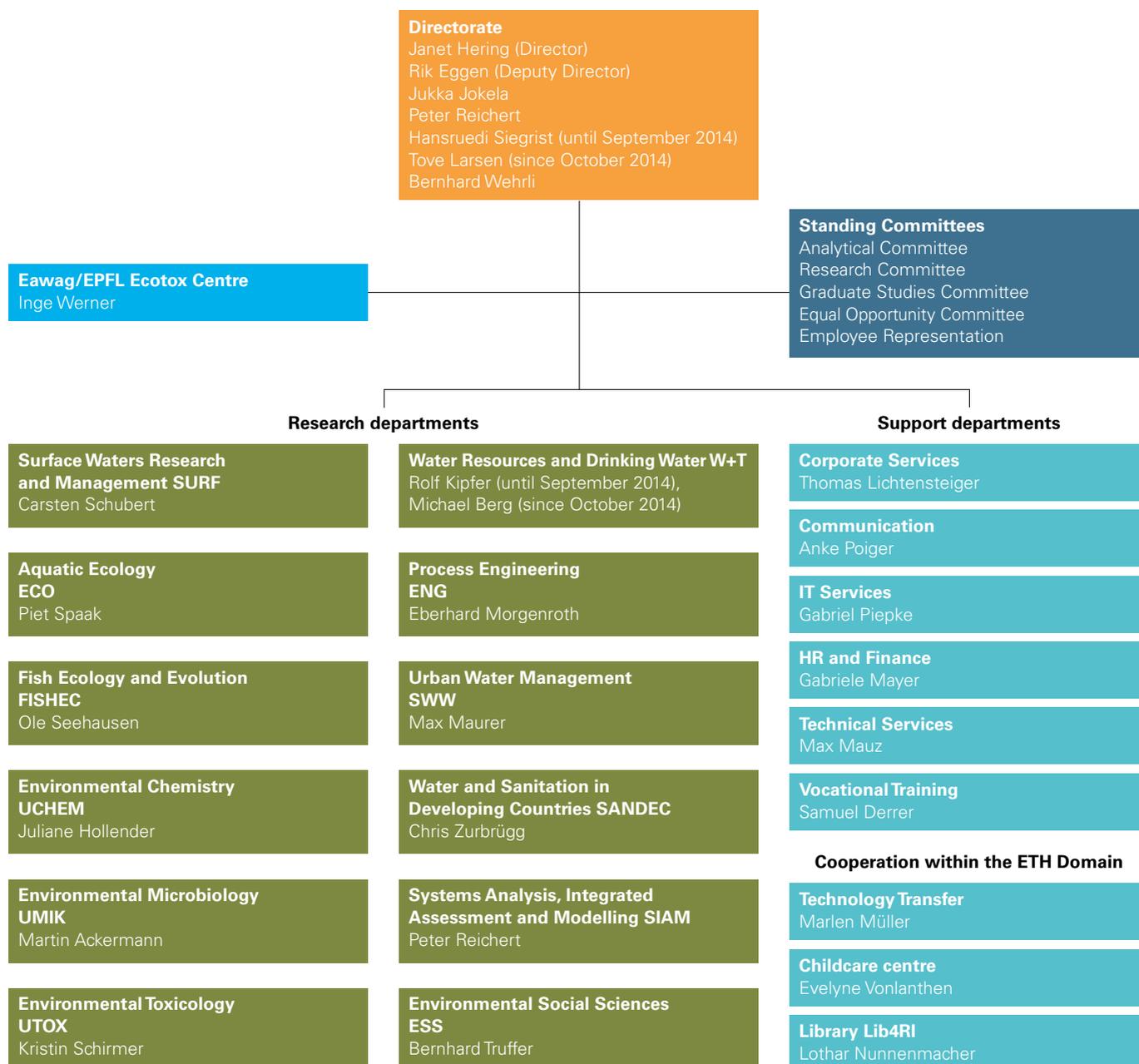
managing scientific information, the publication process and literature management. Because of the strong demand for this programme, the number of course hours offered was doubled in 2014.

**Use of ETH research facilities.** In environmental research, questions of bioinformatics increasingly need to be addressed. The Genetic Diversity Centre (GDC) at the ETH Zurich Institute for Integrative Biology specializes in studies of this kind. Eawag collaborates closely with the GDC and can thus incorporate bioinformatics effectively into aquatic research. It is also intensifying cooperation with other researchers in the Department of Environmental Systems Science at ETH Zurich.

## Directorate



## Organization



## Advisory Board

**Ursula Brunner** (Chair), Ettler Suter law firm, Zurich

**Claus Conzelmann**, Vice President for Safety, Health and Environmental Sustainability, Nestlé Group

**Heinz Habegger**, Head of Water and Waste Management Office (AWA), Canton Bern

**Gabi Hildesheimer**, FehrAdvice & Partner AG, Zurich

**Peter Hunziker**, Director, Hunziker Betatech AG, Winterthur

**Martin Sager**, Director, Swiss Gas and Water Industry Association, Zurich

**Michael Matthes**, Head of Environment, Safety & Technology, Science Industries Business Association, Zurich

**Stephan R. Müller**, Head of Water Division, Federal Office for the Environment, Bern

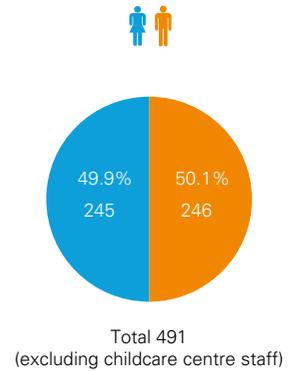
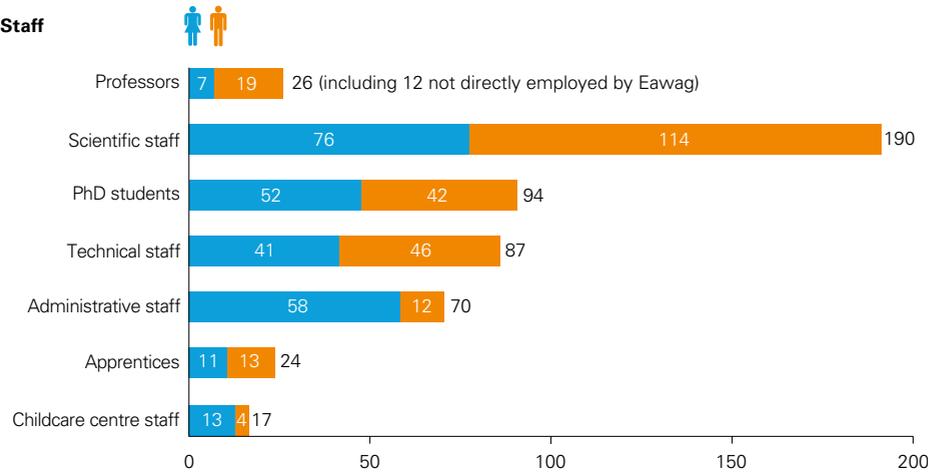
**Reto Schneider**, Head of Emerging Risk Management, Swiss Re, Zurich

**Felix von Sury**, Consultant, Von Sury Consulting, Solothurn

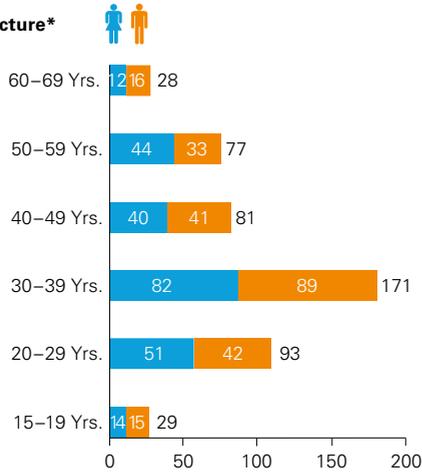
**Thomas Weibel**, National Councillor, Green Liberal Party, Canton Zurich

## Personal

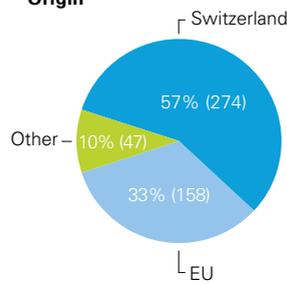
### Staff



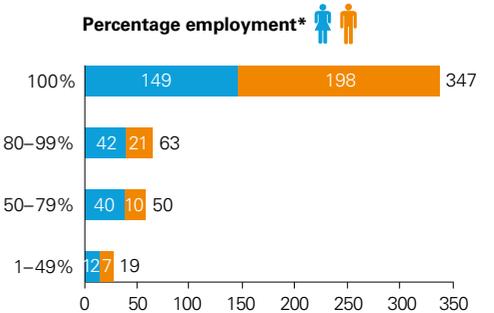
### Age structure\*



### Origin\*



### Percentage employment\*\*

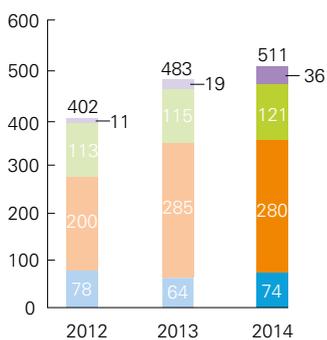


\*Excluding childcare centre staff and 12 not directly employed by Eawag

## Research

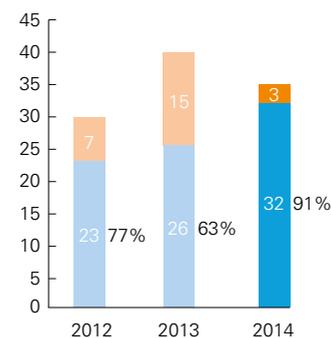
### Publications

Impact factor > 8 (purple)  
 Impact factor 4-8 (green)  
 Impact factor < 4 (orange)  
 Non-refereed (blue)



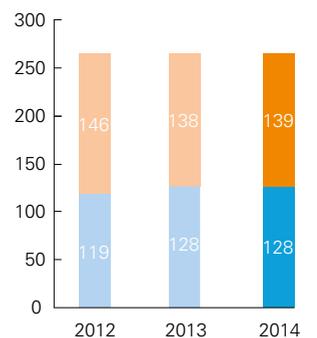
### Swiss National Science Foundation research proposals

Approved (blue thumbs up)  
 Not approved (orange thumbs down)



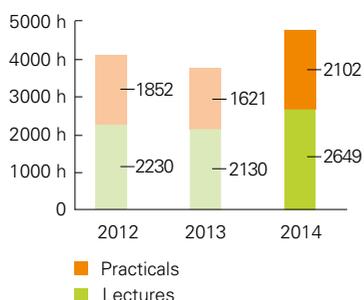
### Committee memberships

National committees (blue)  
 International committees (orange)

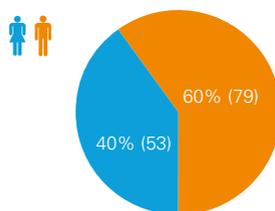


## Teaching

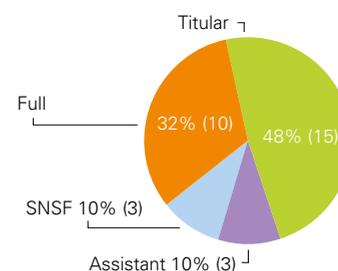
Teaching hours



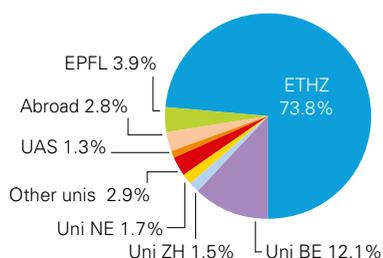
Lecturers



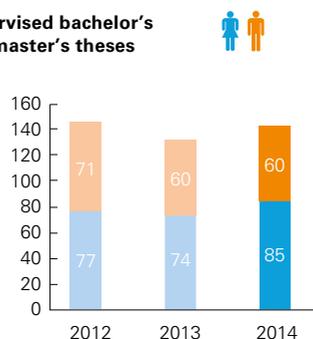
Professorships



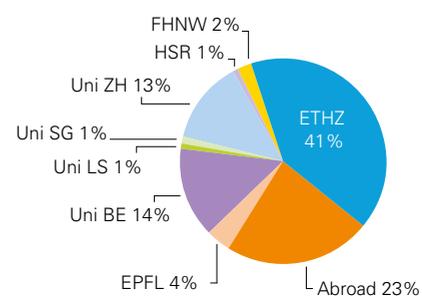
Tertiary-level teaching



Supervised bachelor's and master's theses



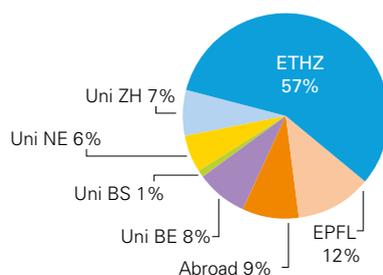
Student home institutions



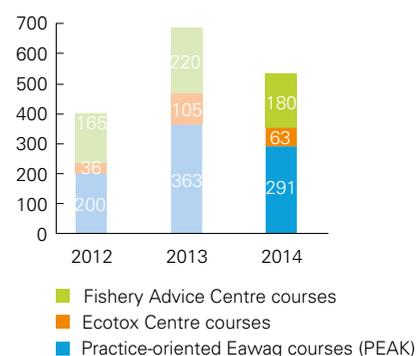
Supervised dissertations



PhD student home institutions



Practical education and training (participants)



## Awards

**Award**

- Global Project Innovation Award, International Water Association
- IAMOT Research Publication Award, International Association for Management of Technology
- RIFCON Best Publication Award, Society of Environmental Toxicology and Chemistry Europe
- Social Impact Award, Journals of Service Management
- Engineering Award, School of Engineering, University of KwaZulu-Natal
- Otto Jaag Water Protection Prize, TH Zurich
- Huber Technology Prize, Huber Technology Foundation
- ETH Medal for Doctoral Dissertation, ETH Zurich
- ETH Medal for Doctoral Dissertation, ETH Zurich
- ETH Medal for Master thesis, ETH Zurich
- ETH Medal for Master thesis, ETH Zurich

**Recipient**

- Blue Diversion Toilet
- Bernhard Truffer, Environmental Social Sciences
- Stephan Fischer, Environmental Toxicology
- Heiko Gebauer, Environmental Social Sciences
- Eawag
- Lisa Scholten, System Analysis
- Alexandra Fumasoli, Process Engineering
- Pascal Wunderlin, Process Engineering
- Tobias Sommer, Surface Waters
- Michael Besmer, Environmental Microbiology
- Heidi Käch, Aquatic Ecology

## Finances

### Financial statement 2014

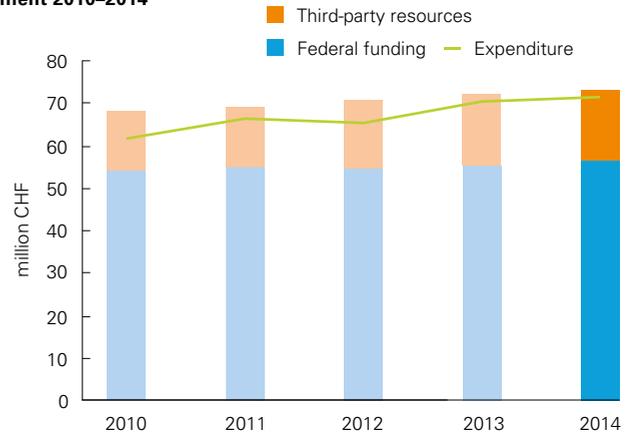
Personnel	47 316 048
Materials	2 596 998
Operations and infrastructure	17 052 686
Depreciation	2 386 224
Provisions	2 102 976
<b>Expenditure</b>	<b>71 454 932</b>
Federal government funding	56 851 494
Third-party resources	16 443 753
Miscellaneous revenue	825 684
<b>Income</b>	<b>74 120 931</b>
<b>Result</b>	<b>2 665 999</b>

### Investments 8 883 961

Real estate	6 936 005
Movable	1 919 189
IT	28 767

all figures in CHF

### Development 2010–2014

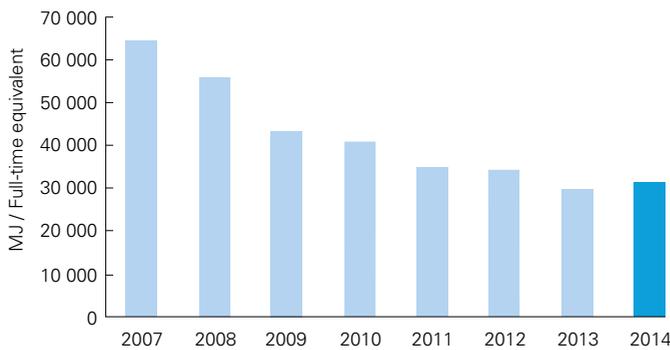


### Third-party resources 2014

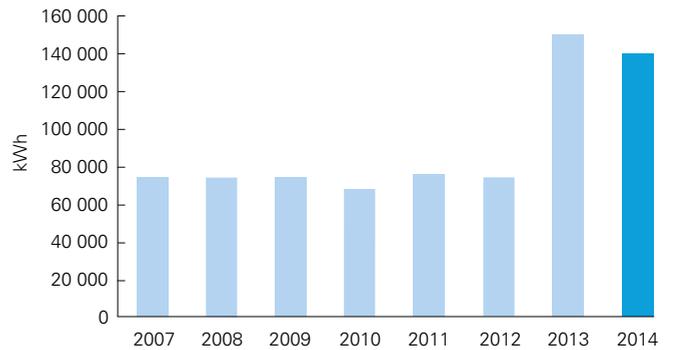


## Environment

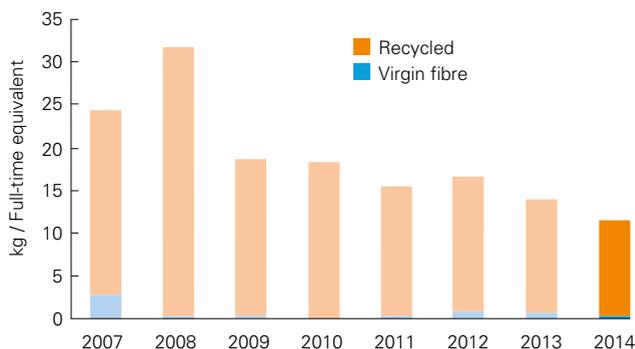
### Energy consumption per capita



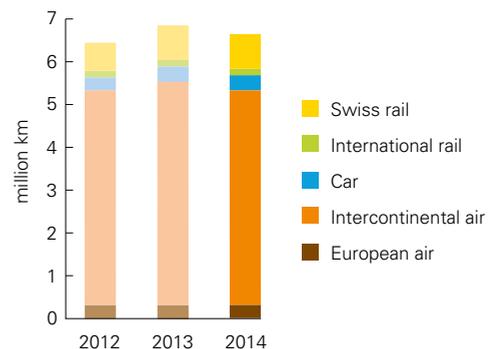
### Photovoltaic electricity generation



### Paper consumption per capita



### Business travel



The Annual Report 2014 presents only a small selection of Eawag's research, teaching and consulting activities. A database of all publications by Eawag researchers (including summaries of articles) is available online at: [www.lib4ri.ch/institutional-bibliography/eawag.html](http://www.lib4ri.ch/institutional-bibliography/eawag.html). Open access publications can be downloaded free of charge.

The Annual Report is also available in German and French.

Publication details

Editing: Andres Jordi / Contributors: Irene Bättig (Sprachwerk), Anke Poiger  
Layout: Peter Penicka

Translation: Jeff Acheson, Laurence Frauenlob

© Eawag, May 2015

Reproduction is permissible with citation of the source:

"Eawag – Aquatic Research: Annual Report 2014".

Specimen copies to: Eawag, Kommunikation, Postfach 611, 8600 Dübendorf

Eawag, Überlandstrasse 133, Postfach 611, 8600 Dübendorf

Phone +41 (0)58 765 55 11, fax +41 (0)58 765 50 28

Eawag, Seestrasse 79, 6047 Kastanienbaum

Phone +41 (0)58 765 21 11, fax +41 (0)58 765 21 68

[www.eawag.ch](http://www.eawag.ch)

Eawag  
Überlandstrasse 133  
Postfach 611  
8600 Dübendorf  
Phone +41 (0)58 765 55 11  
Fax +41 (0)58 765 50 28  
www.eawag.ch  
info@eawag.ch

# Contents

<b>Editorial</b>	1
<b>Highlights of 2014</b>	2
<b>Research</b>	
World-class research supporting practice and policymaking	4
<b>Teaching</b>	
Valued experts and distinguished young researchers	10
<b>Consulting</b>	
Permanent dialogue and close collaboration with stakeholders	14
<b>Institution</b>	
Attractive employment conditions for outstanding performance	18
Directorate and organization	24
Eawag in figures	26